

# GANGRENE

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## DRY GANGRENE OF THE TOES

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A 65-year-old male patient with type 2 diabetes diagnosed at the age of 61 years and treated with sulfonylurea, was admitted to the Vascular Surgery Department. He was a heavy smoker and had a sedentary lifestyle. He had hypertension, background diabetic retinopathy and dyslipidemia (triglycerides: 4 mmol/l; HDL-cholesterol: 0.67 mmol/l). His diabetes control was poor ( $HbA_{1c}$ : 8.5%). The patient complained that in the previous 3 weeks he had experienced pain which required analgesia when he was at rest. He had typical symptoms of intermittent claudication for 2 years with progressive worsening.

On examination, extensive dry gangrene was found involving all the toes and with a necrotic area over the dorsum of his left foot (Figure 7.1). The foot arteries and left popliteal artery could not be felt, while the femoral arteries were just palpable bilaterally. Pulses in the right foot arteries were absent; the skin was cold and the right popliteal artery was just palpable. The ankle brachial index was 0.4. The patient had reduced sensation of pain, light touch and temperature. The vibration perception threshold was 35 V on the left and 30 V on the right foot. Critical limb ischemia with dry gangrene was diagnosed; an angiogram showed extensive stenosis of the common iliac, superficial femoral and popliteal arteries of both feet. Aorto-femoral and femoro-popliteal bypass grafts were undertaken 2 days after admission, followed by mid-tarsal disarticulation (at Lisfranc's joint). The postoperative period was without any complications and the wound healed completely.

Gangrene is characterized by the presence of cyanotic, anesthetic tissue associated with

or progressing to necrosis. It occurs when the arterial blood supply falls below minimal metabolic requirements. Gangrene can be described as dry or wet. Wet gangrene is dry gangrene complicated by infection (see below, and Figures 7.24 and 7.25).

Dry gangrene is characterized by its hard, dry texture, usually occurring in the distal aspects of the toes, often with a clear demarcation between viable and necrotic tissue. Once demarcation occurs, as is the case in this patient, the involved toes may be liable to auto-amputation. However, this is a long (several months) and unpleasant process. In addition, many patients do not have an adequate circulation to heal a distal amputation. For these reasons it is common practice to evaluate the arteries angiographically and to carry out a bypass or a percutaneous transluminal angioplasty with concomitant limited distal amputation, in order to improve the chances of wound healing.

## CRITICAL LEG ISCHEMIA

Critical leg ischemia is defined — according to the consensus statement on critical limb ischemia — as either of the following two criteria: *persistently recurring ischemic rest pain*, requiring regular adequate analgesia for more than 2 weeks, with an ankle systolic pressure  $\leq 50$  mmHg and/or a toe pressure  $\leq 30$  mmHg; or *ulceration or gangrene* of the foot or toes, with an ankle systolic pressure  $\leq 50$  mmHg and/or a toe pressure  $\leq 30$  mmHg. In such patients it is important to differentiate neuropathic pain from ischemic rest pain (neuropathic pain typically occurs or worsens at rest in the night). Measurement of the ankle brachial index or toe pressure can easily differentiate the two conditions.

**Keywords:** Dry gangrene; critical limb ischemia



**Figure 7.1** Dry gangrene involving all the toes of the left foot with a necrotic area over the mid-dorsum. Note the hard, dry texture and the clear demarcation between viable and necrotic tissue. (Courtesy of E. Bastounis)

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### **DRY GANGRENE WITH ISCHEMIC NECROSIS OF THE SKIN**

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Dry gangrene in a female patient with type 2 diabetes, involving the distal parts of the toes of her right foot is illustrated in [Figure 7.2](#). The pedal arteries were not palpable and the ankle brachial index was 0.4. A well-demarcated red area extended up to the ankle and the lateral foot, indicating ischemic necrosis of the skin. Angiography showed the patient to have multilevel severe atherosclerotic disease with involvement of the tibial and pedal arteries. An attempt at mid-tarsal (at Lisfranc's joint) disarticulation was unsuccessful, as it was discovered during the operation that the deep tissues were all necrotic. Finally, the patient sustained a below-knee amputation.

**Keywords:** Dry gangrene



**Figure 7.2** Dry gangrene of the distal areas of the toes of the right foot. The well-demarcated red area extending up to the ankle and the lateral foot indicates ischemic necrosis of the skin. (Courtesy of E. Bastounis)

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### **DRY GANGRENE OF HEEL**

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A 74-year-old female patient with long-standing type 2 diabetes was admitted to the hospital because of a stroke. She had palsy of her left arm and foot. Her hospitalization was complicated by aspiration pneumonia, which confined the patient to bed for 2 weeks. The patient had a history of ischemic heart disease and hypertension. Peripheral pulses were weak in both feet. On the sixth day of her hospitalization a blister with a black base developed on the posterolateral aspect of her left foot, and it evolved into an ischemic ulcer and dry gangrene ([Figure 7.3](#)). A triplex ultrasonogram revealed extensive severe bilateral stenoses in the superficial femoral and popliteal arteries. Revascularization was not possible

due to the patient's general condition. A heel protector ring was applied so that the heel was completely suspended off the bed and sharp debridement was performed. The ulcer healed after 4 months with daily foot care.

Pressure ulcers are caused by constant pressure over bony heel prominences from an opposing surface such as a mattress. This results in reduced blood flow in the heel with soft tissue necrosis and consequent pressure ulcer development. These ulcers may account for extended hospitalizations and they are recognized as both detrimental to an individual's quality of life and a financial burden to the healthcare system. Pressure ulcers of the heel are preventable by the use of a heel protector ring ([Figure 7.4](#)) or other calf support devices ([Figure 7.5](#)). Since the calf has a large resting surface



**Figure 7.3** Dry gangrene due to constant pressure under the bony heel prominence

excessive pressure is avoided. In addition, revascularization should be performed immediately in patients with heel gangrene, since such ulcers heal slowly and may become infected.

**Keywords:** Heel ulcer; dry gangrene; pressure ulcer; heel protective devices



**Figure 7.4** Heel protector ring which keeps the heel suspended and completely off mattress

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### DRY GANGRENE OF ALL TOES

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Dry gangrene in a male diabetic patient involving all the toes is shown in [Figure 7.6](#). In this patient a bypass graft of his leg arteries was not possible because of extensive multilevel disease. The patient sustained a mid-tarsal (at the Lisfranc's joint) disarticulation.

**Keywords:** Dry gangrene; mid-tarsal disarticulation

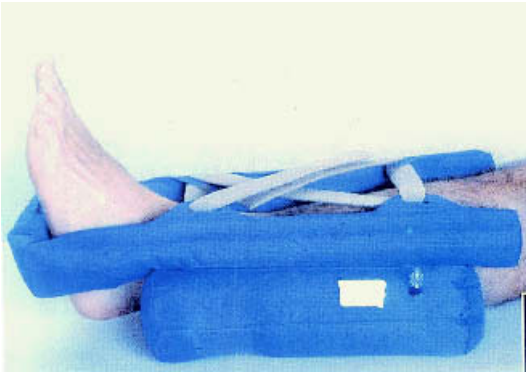
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### WET GANGRENE AND SEPSIS

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A 65-year-old male patient who had type 2 diabetes since the age of 45 years and was being treated with sulfonylureas, was brought to the emergency clinic suffering from a fever. He had left paraplegia following a stroke 6 months earlier. One month before admission the toes of his left foot became gradually very painful;

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**Figure 7.5** Calf support device which provides a larger resting surface thus off-loading pressure from the heel



**Figure 7.6** Dry gangrene of all toes



**Figure 7.7** A black ischemic ulcer on the dorsum of the left second toe, with edema. Note the whitish tip of the toe due to ischemia. Fungal infection of the thickened nail of hallux with yellowish discoloration and subungual debris is apparent

the patient was usually calm, but occasionally he suffered from bouts of excruciating pain. A general practitioner prescribed cotrimoxazole, pentoxifyllin and fentanyl patches.

On examination, the patient was febrile and his condition was critical. His second left toe was edematous and painful, with a black ischemic ulcer on the dorsum; the tip of the toe was white ([Figure 7.7](#)); a gangrenous pressure ulcer was visible on the left heel ([Figure 7.8](#)), due to lengthy confinement to bed. Callosity was present under the right fifth metatarsal head, as well as onychodystrophy, due to peripheral vascular disease. No pulses were palpable on his left foot. Both his calves were painful to touch. No other site of infection was found. The patient was classified as Fontaine stage IV. Osteomyelitis was

not found on the radiographs. Swab cultures revealed *Staphylococcus aureus* and *Pseudomonas aeruginosa* and the patient was treated with ciprofloxacin and clindamycin. Blood cultures were negative. On the second day the patient felt better and became afebrile by the third day of hospitalization.

A digital subtraction angiography, carried out 10 days after admission, showed 80% stenosis of both iliac arteries, and almost complete obstruction of both superficial femoral arteries ([Figure 7.9](#)), while the popliteal arteries were filled from proximal collateral circulation ([Figure 7.10](#)). The peripheral arteries had moderate atheromatous disease. Aorto-iliac intravascular stents were inserted ([Figure 7.11](#)).

His second left toe was disarticulated. Surgical debridement of the heel ulcer was



**Figure 7.8** Low pressure gangrenous ulcer on the left heel of the foot shown in [Figure 7.7](#)

carried out and calf supportive devices promoted the healing process.

An infected gangrenous area of the foot and particularly on a toe with bounding feet pulses is a condition that is sometimes seen. This is called '*diabetic gangrene*' and it is caused by a thrombosis in the toe arteries which is induced by toxins produced by certain bacteria (mainly staphylococci and streptococci). Plantar abscesses may also result in septic arteritis of the plantar arch and eventually gangrene of the middle toe.

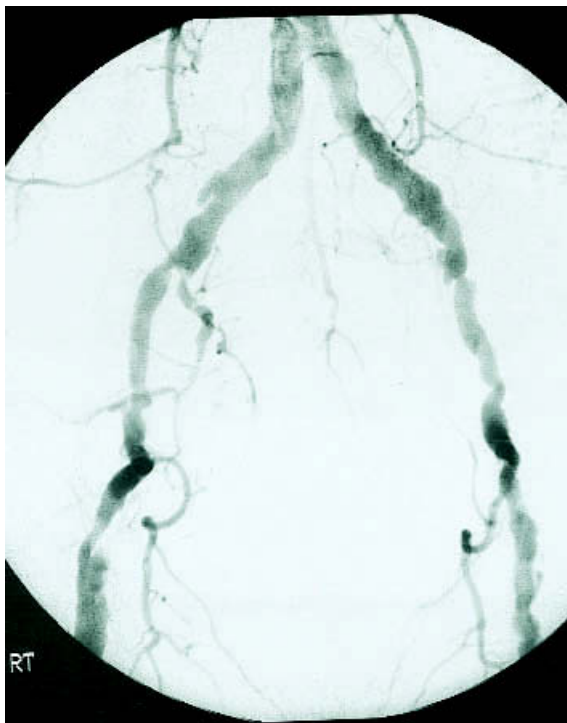
**Keywords:** Wet gangrene; sepsis; heel ulcer; digital subtraction arteriography; diabetic gangrene

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### DRY GANGRENE OF THE TOE

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A 52-year-old woman with type 2 diabetes mellitus diagnosed at the age of 42 years and being treated with sulfonylureas, was referred to the outpatient diabetic foot clinic



**Figure 7.9** Digital subtraction angiography of the foot illustrated in Figures 7.7 and 7.8, showing severe multifocal stenosis of both iliac arteries and almost complete obstruction of both superficial femoral arteries

for dry gangrene of her right fourth toe. No other diabetic complications were reported. She denied intermittent claudication.

A minor painless trauma of the affected toe was reported 1 week previously and the toe became black 24 h later. Edema and redness of the forefoot was reported and she was treated with cotrimoxazole and clindamycin, and bed rest. Within a week the injury became smaller and dried out.

On examination, she had findings of peripheral neuropathy; the pulses in her foot arteries were diminished. The ankle brachial index was 0.5 on the right, and 0.6 on the left side.

The fourth toe was gangrenous and shrunken, and a neuro-ischemic ulcer was noted under the head of the third metatarsal. Scaling of the skin due to edema which had subsided was also observed and onychodystrophy was present (Figure 7.12). Digital

subtraction angiography revealed significant stenosis of both proximal iliac arteries, just after the celiac aortic bifurcation (Figure 7.13). Aortic stents were inserted at the sites of stenosis, by catheterization which was carried out by an experienced radiologist, and the foot circulation was thus restored (Figure 7.14).

An X-ray of her left foot revealed an unknown stress fracture in the proximal phalanx of her fifth toe (Figure 7.15). Osteoarthritis was also apparent in the first and fourth metatarsophalangeal joints.

Ten days after stent insertion the fourth toe was amputated under local anesthesia. No complications occurred postoperatively, and the wound healed completely.

**Keywords:** Dry gangrene; intravascular stent; stress fracture; revascularization; toe amputation



**Figure 7.10** Digital subtraction angiography of the foot illustrated in Figures 7.7–7.9, showing the popliteal arteries being supplied from extensive proximal collateral vessels. (Courtesy of C. Liapis)

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## STENT

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A 71-year-old male patient was admitted because of gangrene in his left foot. Diabetes mellitus was diagnosed on admission and he was treated with low doses of insulin. Antibiotic therapy was initiated, in addition to pentoxifyllin, prostaglandin E1 synthetic analog and phentanyl for the pain. A digital subtraction angiography was carried out which disclosed multiple sites of stenosis in both iliac and superficial femoral arteries (Figure 7.16 upper panel, and Figure 7.17). A suboptimal angioplasty

was carried out on both arteries and stents were inserted (Figure 7.16 lower panel, and Figure 7.18).

During percutaneous transluminal angioplasty a balloon catheter is used to increase the diameter of the lumen of the arteriosclerotic artery. This is a quite safe and minimally invasive technique (as compared to surgery); it preserves saphenous veins, and reduces the length of hospital stay. However, this procedure fails more often in diabetic than in non-diabetic patients due to intimal hyperplasia.

Stents are used to treat suboptimal angioplasty, lesions with severe dissections or



**Figure 7.11** Post-stent digital subtraction angiography of foot shown in Figures 7.7–7.10. (Courtesy of C. Liapis)



**Figure 7.12** Dry gangrene of right fourth toe. There is a neuro-ischemic ulcer under the third metatarsal head



**Figure 7.13** Digital subtraction angiography of the foot shown in [Figure 7.12](#). Severe stenosis following the bifurcation of celiac aorta can be seen

significant residual stenosis after angioplasty. The first endovascular stent approved for use in the iliac arteries was the Palmaz stent, a single stainless steel tube, deployed by balloon expansion. The Wall-stent, a flexible self-expanding stent which is available in several different diameter sizes, is also in use. New, covered stents are being evaluated, with the hope that they may mimic surgical grafts and resist re-stenosis.

**Keywords:** Stents; peripheral vascular disease; angioplasty; digital subtraction angiography

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### DIGITAL SUBTRACTION ANGIOGRAPHY

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A 54-year-old female suffering from type 2 diabetes and being treated with metformin



**Figure 7.14** Post-stent digital subtraction angiography of the foot shown in Figures 7.12 and 7.13. (Courtesy of C. Liapis)

and insulin, was admitted to the vascular surgery ward; she complained of worsening intermittent claudication in her right leg which had occurred over the previous 2 months. As her ankle brachial index was very low (0.4), a digital subtraction angiography of the abdominal aorta and the arteries of the lower extremities was carried out.

A catheter was inserted through her right brachial artery and the tip of the catheter was advanced into the abdominal aorta.

Advanced stenotic lesions of the abdominal aorta were present with partial stenosis of the lumen. The iliac and common femoral arteries were patent.

Severe stenoses in the superficial femoral arteries were present, predominantly in the right vessel, with a subtotal occlusion of the distal area of the artery (Figures 7.19 and 7.20); extensive collateral vessel development was noted and both popliteal arteries were fairly patent. There was mild atheromatous disease in the tibial arteries.

Digital subtraction angiography has replaced film screen angiography since it provides superior contrast resolution and the capability of post-processing the data. It uses less contrast and maximizes guidance for minimally invasive therapy.

**Keywords:** Peripheral vascular disease; digital subtraction angiography



**Figure 7.15** Plain radiograph of the foot shown in [Figures 7.12–7.14](#). A stress fracture of the proximal phalanx of the fifth toe and osteoarthritis in the first and fourth metatarsophalangeal joints can be seen

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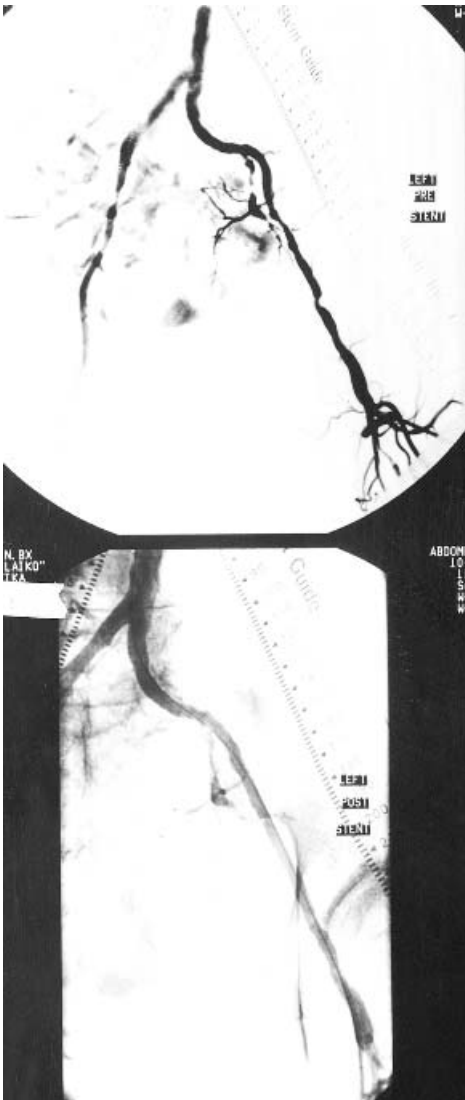
### **WET GANGRENE OF THE TOES**

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A 54-year-old male patient with type 2 diabetes diagnosed at the age of 49 years was admitted to the Vascular Surgery Department because of wet gangrene involving the toes of his left foot. He had been treated with sulfonylurea over the previous 8 years which had led to acceptable diabetes control (HBA<sub>1c</sub>: 7.5%). The patient was an ex-smoker. During the last 10 years he had also suffered from hypertension which had been treated with an angiotensin converting enzyme inhibitor and a diuretic. He had typical intermittent claudication with

pain in both calves while walking distances of 150 m.

On examination, wet gangrene was noted on the fourth and fifth toes of his left foot. An infected area of ischemic necrosis was also present on the dorsal aspect of his left third toe ([Figure 7.21](#)). The peripheral pulses were absent and the ankle brachial pressure index was 0.4 bilaterally; he also had findings of mild peripheral neuropathy. The patient was in quite severe pain, and he was treated with systemic analgesics and i.v. antibiotics (ticarcillin–clavulanic acid and clindamycin). An angiogram revealed multifocal atheromatous lesions of both iliac and superficial femoral arteries ([Figure 7.22](#)), as



**Figure 7.16** Digital subtraction angiography showing multiple sites of stenosis in both iliac and superficial femoral arteries (upper panel). Stent inserted in left superficial femoral artery (lower panel). (Courtesy of C. Liapis)

well as increased development of collateral vessels. A proximal stenosis was noted on both tibial and peroneal arteries. A femoral–popliteal bypass graft and,

eventually, a ray amputation of the last two toes were carried out and the wound was left open for drainage.

Atherosclerotic lesions in diabetic patients occur at sites similar to those in non-diabetics (such as sites of arterial bifurcation), while more advanced disease is common in diabetic patients affecting even collateral vessels. The pathology of the affected arteries is similar in both diabetics and non-diabetics. Typical atherosclerotic lesions of diabetic patients with peripheral vascular disease include diffuse multifocal stenosis. In addition, diabetic peripheral vascular disease has a predilection for the tibioperoneal arteries. All tibial arteries may be occluded with distal reconstitution of a dorsal pedal or common plantar artery. Atherosclerosis begins at a younger age and progresses more rapidly in diabetics than in non-diabetics. While non-diabetic men are affected by peripheral vascular disease much more commonly than non-diabetic women (men-to-women ratio 30:1), the incidence among diabetic men is twice that observed among diabetic women.

**Keywords:** Peripheral vascular disease; wet gangrene; digital subtraction angiography

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## WET GANGRENE OF THE FOOT

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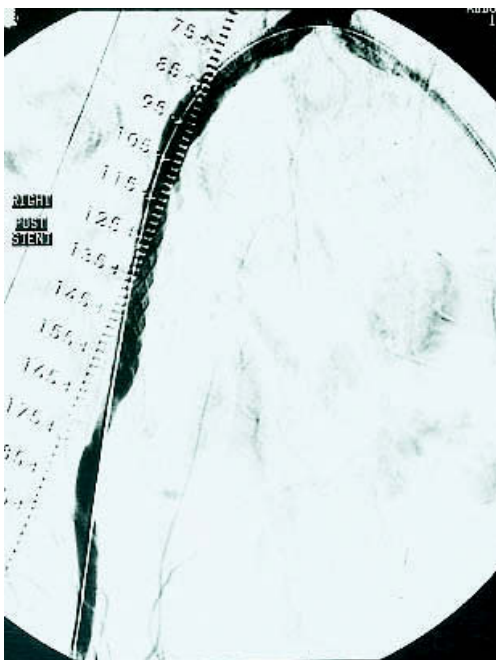
Gangrene complicated with infection (wet gangrene) in a patient with longstanding type 2 diabetes. Redness and edema, due to infection, extended up to the lower third of the tibia (Figure 7.23). In this patient a below-knee amputation was necessary.

**Keywords:** Wet gangrene

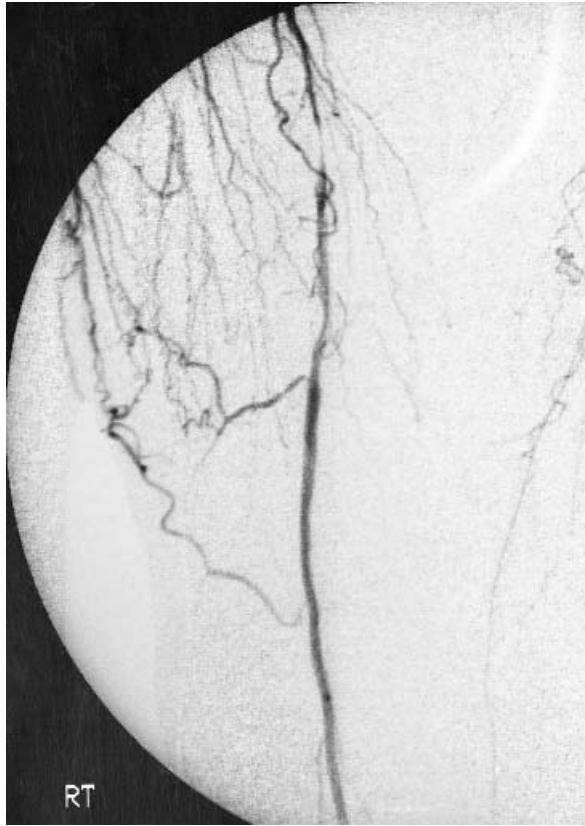
## *Gangrene*



**Figure 7.17** Digital subtraction angiography of the foot illustrated in [Figure 7.16](#), showing multiple sites of stenosis in right superficial femoral artery. (Courtesy of C. Liapis)



**Figure 7.18** Digital subtraction angiography of the foot shown in [Figures 7.16](#) and [7.17](#). Stent inserted in right superficial femoral artery. (Courtesy of C. Liapis)



**Figure 7.19** Digital subtraction angiography. Severe stenoses in the right superficial femoral artery with extensive collateral vessel development. (Courtesy of C. Liapis)

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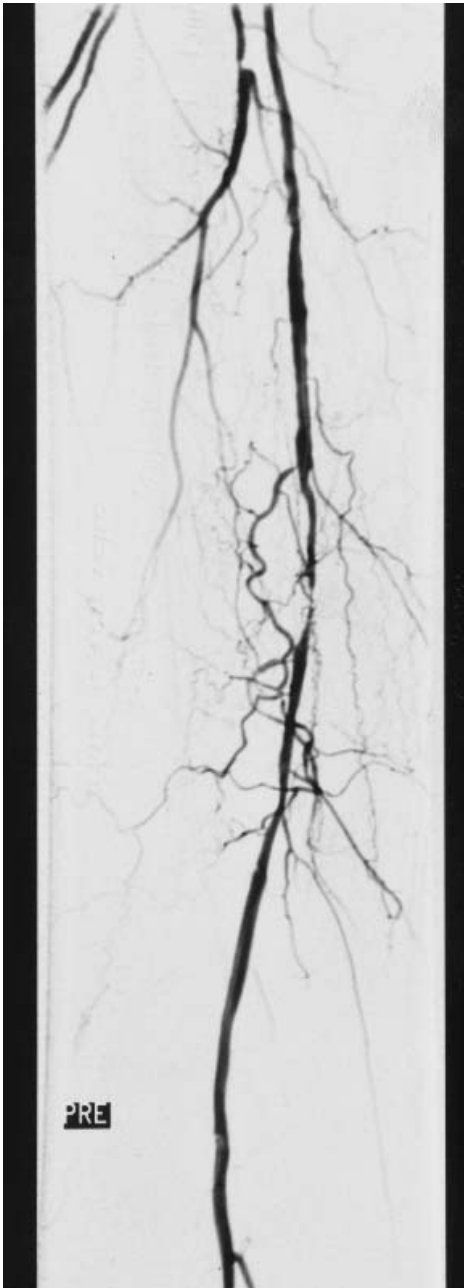
### **WET GANGRENE LEADING TO MID-TARSAL DISARTICULATION**

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A 70-year-old male patient who had type 2 diabetes since the age of 58 years was referred to the outpatient diabetic foot clinic because of wet gangrene of his left foot. He was treated with insulin but his diabetes control was poor. He had hypertension, background diabetic retinopathy and he was a current smoker. The patient noticed black areas on the toes of his foot 7 days previously, but he continued his daily activities since he felt only mild pain.

On examination, he was feverless and his cardiac rhythm was normal. Wet gangrene on his left midfoot and forefoot and an infected necrotic ulcer on the outer aspect of the dorsum were noted (Figure 7.24). An infected ulcer was found under the base of his fifth toe (Figure 7.25), probably the portal of pathogens. Peripheral pulses were absent. He had findings of diabetic neuropathy: loss of sensation of pain, light touch and vibration.

The patient was admitted to the hospital and was treated with i.v. administration of clindamycin plus piperacillin–clavulanic acid. Extensive surgical debridement of the necrotic areas was carried out. An angiogram revealed diffuse peripheral



**Figure 7.20** Digital subtraction angiography of the foot shown in [Figure 7.19](#). Multilevel stenoses of the left superficial femoral artery. (Courtesy of C. Liapis)

vascular disease with involvement of the pedal arteries. Seven days after admission the patient sustained a mid-tarsal (at Lisfranc's joint) disarticulation.

Wet gangrene is the most common cause of foot amputations in persons with diabetes. It often occurs in patients with severe peripheral vascular disease following infection. Dry gangrene may become infected and progress to wet gangrene. Patients with dry gangrene, awaiting a surgical procedure, should be educated in meticulous foot care. They must be taught to inspect their feet daily, including the interdigital spaces, and wash them twice daily with mild soap and lukewarm water; their feet should be dried thoroughly, particular the web spaces. It is extremely important for patients to avoid wet dressings and debriding agents, as the use of these may convert localized dry gangrene to limb-threatening wet gangrene. The correct footwear is crucial to avoid further injury to the ischemic tissue.

**Keywords:** Wet gangrene; mid-tarsal disarticulation

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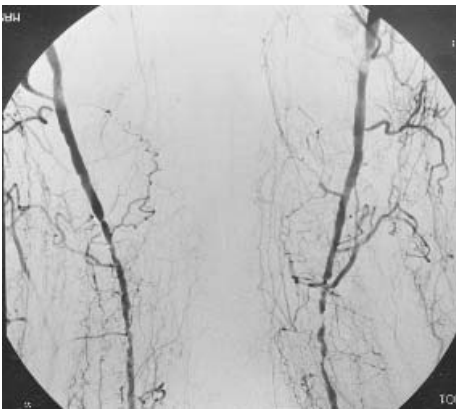
### EXTENSIVE WET GANGRENE OF THE FOOT

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A 51-year-old male patient with type 1 diabetes diagnosed at the age of 25 years was admitted to the Vascular Surgery Department because of extremely painful wet gangrene on his right foot. The patient had proliferative diabetic retinopathy which had been treated with laser, significant loss of his visual acuity (3/10 in both eyes), hypertension and diabetic nephropathy. He had lived in a nursing home. His diabetes control was good ( $HbA_{1c}$ : 7%). The patient had complained of pain in his right foot when he was at rest, 4 weeks prior to



**Figure 7.21** Wet gangrene of the last two toes. An infected area of ischemic necrosis is also apparent on the dorsal aspect of the third toe. (Courtesy of E. Bastounis)



**Figure 7.22** Digital subtraction angiography of the foot shown in [Figure 7.21](#). Multifocal atheromatous lesions of both iliac and superficial femoral arteries and increased development of collateral vessels can be seen. This pattern of arterial obstruction is considered typical in diabetes. (Courtesy of E. Bastounis)

admission; the pain worsened progressively and had become refractory to analgesics in the last 2 days. He denied any trauma to his feet. The patient had fever ( $38.7^{\circ}\text{C}$ ) with rigors and tachycardia; his hemoglobin level was 10 g/l and his white blood cell count was 16,000/l.



**Figure 7.23** Wet gangrene of the right foot. Redness and edema due to infection extends as far as the lower third of the tibia. (Courtesy of E. Bastounis)

## *Gangrene*



**Figure 7.24** Wet gangrene of midfoot and forefoot in addition to an infected necrotic ulcer on the outer aspect of the dorsum. (Courtesy of E. Bastounis)



**Figure 7.25** An infected ulcer under the base of the fifth toe of the patient whose foot is shown in [Figure 7.24](#), probably the portal for pathogens. Gangrene of second toe and mild callus formation under the third metatarsal head can also be seen. (Courtesy of E. Bastounis)



**Figure 7.26** Wet gangrene involving the forefoot with cellulitis extending as far as the right ankle. The bone and articular surfaces of the interphalangeal joint of the fourth toe are exposed. Congenital overriding fifth toe and ulceration under the fifth metatarsal is apparent together with onychodystrophy and ingrown nail of hallux. (Courtesy of E. Bastounis)

On examination, he had wet gangrene involving the right forefoot, with cellulitis extending as far as the right ankle (Figure 7.26). The bone and articular surfaces of the interphalangeal joint of the fourth toe were exposed. Ruptured blisters were observed under the right sole (Figure 7.27). The patient was treated with i.v. antibiotics (piperacillin–sulbactam plus metronidazole) while extensive surgical debridement of the necrotic tissue and drainage of the abscess cavities was carried out. *Staphylococcus aureus*, *Escherichia coli* and anaerobic cocci were isolated from a deep tissue culture. An angiograph revealed multilevel atheromatous stenosis of his common femoral, superficial femoral, popliteal and tibial arteries.

The patient had his second and third toes amputated. Extensive longitudinal incisions in the dorsum and the lateral foot were undertaken. Within 2 days his condition worsened rapidly, and he sustained an amputation below his right knee.

Wet gangrene is characterized by a moist appearance, gross swelling and blistering. This is an emergency situation which occurs in patients with severe ischemia who sustain an unrecognized trauma to their toe or foot. Urgent debridement of all affected tissues and use of antibiotics often results in healing if sufficient viable tissue is present to maintain a functional foot together with adequate circulation. If wet gangrene involves an extensive part of the foot, urgent guillotine amputation at a



**Figure 7.27** Sole of the foot shown in [Figure 7.26](#) with wet gangrene of the forefoot, ulceration under fifth metatarsal head and ruptured blisters. (Courtesy of E. Bastounis)

level proximal enough to encompass the necrosis and gross infection, may be life saving. At the same time a bypass surgery or a percutaneous transluminal angioplasty should be performed when feasible. Saline gauze dressings, changed every 8 h, work well in open amputations. Revision to a below-knee amputation may be considered 3–5 days later.

**Keywords:** Wet gangrene; deep tissue infection; onychocryptosis; ingrown nail

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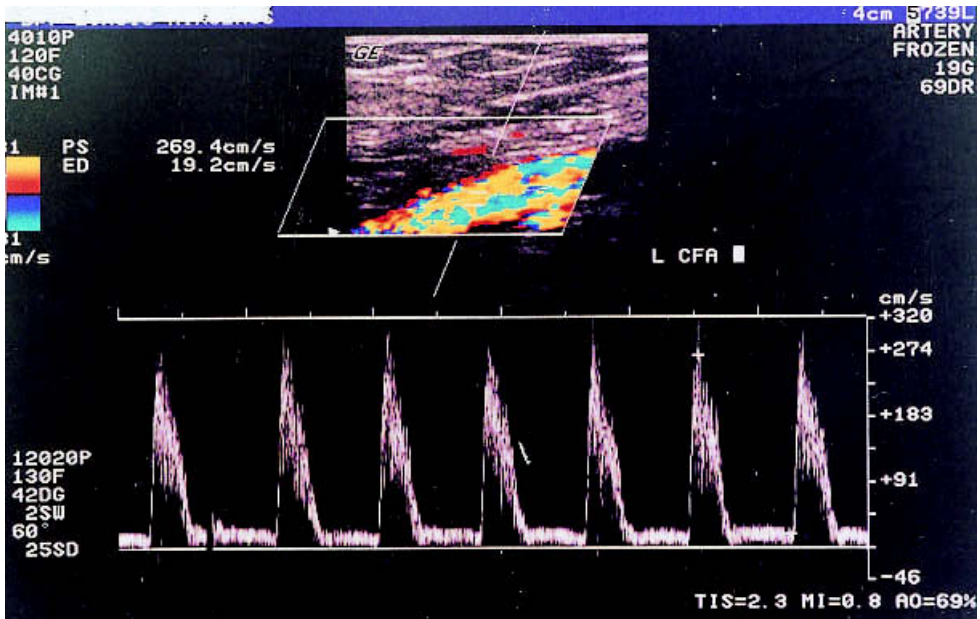
### WET GANGRENE OF THE HALLUX

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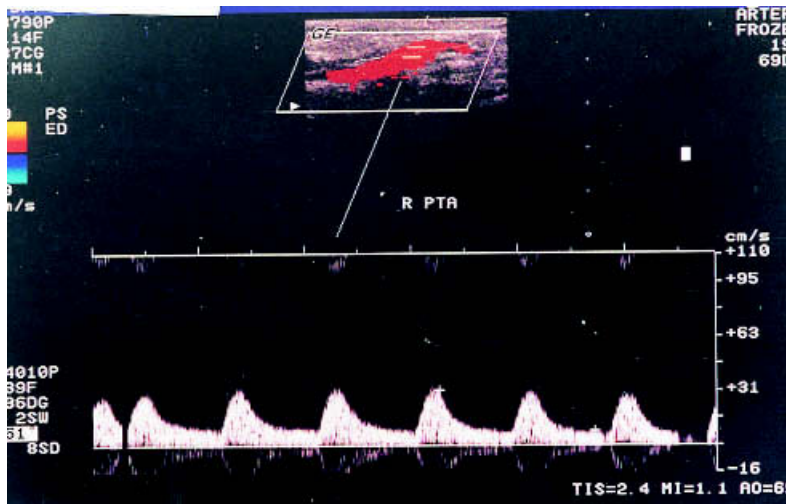
A 72-year-old male patient with type 2 diabetes diagnosed at the age of 60 years and being treated with insulin, attended the outpatient diabetic foot clinic because of pain in his right hallux. His diabetes control was poor (HBA<sub>1c</sub>: 8.7%). He had hypertension and background retinopathy in both eyes. He was an ex-smoker. The patient had



**Figure 7.28** Wet gangrene of the right hallux and claw toe deformity. Ischemic changes (loss of hair, redness over toes, dystrophic nail changes) can also be seen

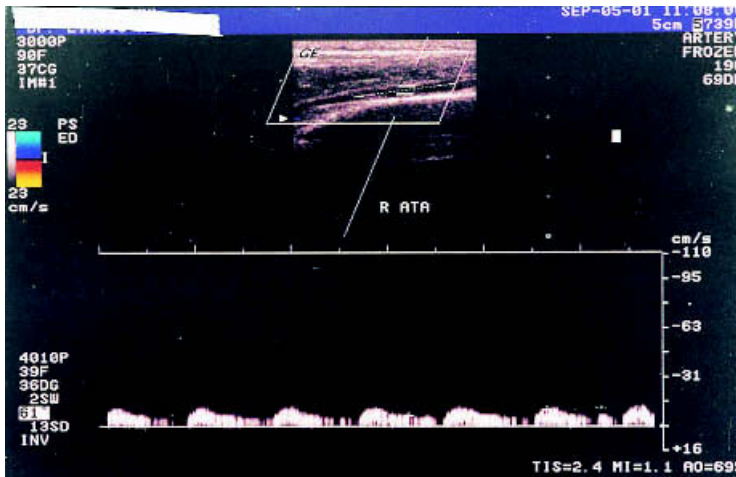


**Figure 7.29** Triplex scan of the foot shown in Figure 7.28. Increased peak systolic velocity (PSV) of blood flow (269 cm/s) through the stenotic segment of the left common femoral artery, biphasic flow pattern and widening of the spectral window under systolic peak can be seen (normal PSV in the common femoral artery is approximately 100 cm/s). These findings correspond to a stenosis of the left common femoral artery of 50–60%

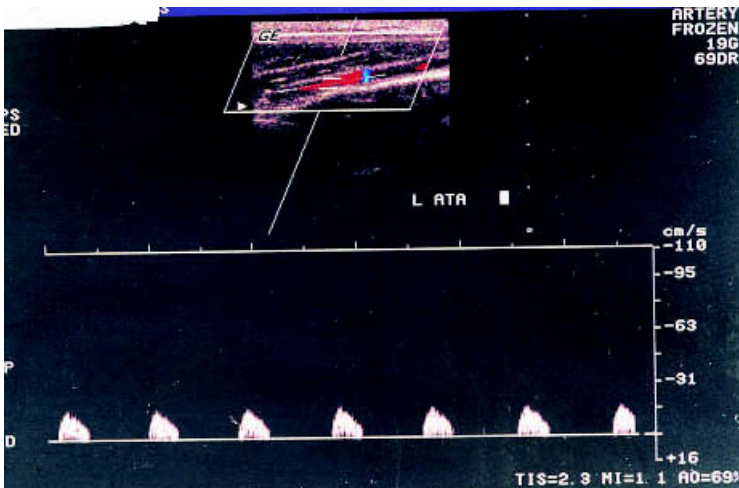


**Figure 7.30** Triplex scan of the foot shown in Figures 7.28 and 7.29. The spectral window in the right posterior tibial artery is biphasic, the spectrum is wide and the peak systolic velocity (PSV) is reduced (PSV at this level is expected to be about 50 cm/s). These findings denote a proximal stenosis of approximately 60%

## Gangrene



**Figure 7.31** Triplex scan of the foot shown in Figures 7.28–7.30. The spectral waveform of the right anterior tibial artery is biphasic, the spectral window is wide, the peak systolic velocity is decreased, the velocity during diastole is increased and the downslope of the waveform is delayed. This pattern of flow is described as *tardus parvus* and corresponds to the presence of a proximal stenosis of 60–70%



**Figure 7.32** Triplex scan of the foot shown in Figures 7.28–7.31. Examination of the left anterior tibial artery shows a monophasic waveform, indicating that a stenosis of greater than 80% is present

ischemic rest pain due to peripheral vascular disease (Fontaine's stage IV). Six days earlier he had become aware of a worsening pain in his right hallux, the onset of which had been acute.

On examination, wet gangrene was noted on the right hallux; peripheral pulses were absent and the ankle brachial index was 0.4 bilaterally. He had severe peripheral neuropathy (no Achilles tendon reflexes, loss of

sensation of 5.07 monofilaments and vibration; the vibration perception threshold was 45 V in both feet) and claw toe deformity. In addition, ischemic changes of his feet were also noted (loss of hair, redness over toes, dystrophic nail changes, and cold feet) (Figure 7.28).

Onychocryptosis was the cause of his gangrene due to inappropriate nail care, resulting in paronychia and localized ischemic necrosis. The patient was treated with amoxicillin–clavulanic acid. A color duplex scan (triplex) of the leg arteries showed mild atheromatous stenosis in his iliac and common femoral arteries (see below), and severe stenosis in his right superficial femoral artery. An angiogram confirmed the ultrasound findings and revealed a >95% stenosis in the middle of his right superficial femoral artery, with the development of collateral circulation. The right anterior tibial artery was almost completely obstructed just after to the popliteal artery trisection; the foot arteries were patent.

The patient underwent a right aorto-popliteal and a popliteal-peripheral bypass. His recovery was good and the infected hallux improved gradually.

Education in foot care was provided. The patient was advised to wear appropriate footwear.

Increased peak systolic velocity (PSV) of blood flow (269 cm/s) through the

stenotic segment of the left common femoral artery, a biphasic flow pattern and widening of the spectral window under the systolic peak were observed (Figure 7.29) (normal PSV in the common femoral artery is approximately 100 cm/s). These findings correspond to a 50–60% stenosis in the left common femoral artery. The spectral window in the right posterior tibial artery (Figure 7.30) was also biphasic, the spectrum was wide and the PSV was reduced (PSV at this level is expected to be about 50 cm/s) indicating that a proximal stenosis of approximately 60% was present. The waveform of the right anterior tibial artery (Figure 7.31) was biphasic, the spectral window was wide, the peak systolic velocity was decreased, the velocity during diastole was increased and the downslope of the waveform was delayed. This pattern of flow is described as *tardus parvus* and corresponds to the presence of a proximal stenosis of 60–70%. Examination of the left anterior tibial artery (Figure 7.32) showed a monophasic waveform, indicating that a stenosis of greater than 80% was present.

**Keywords:** Dry gangrene; dystrophic nails; onychocryptosis; ingrown nail; triplex scanning; peak systolic velocity; evaluation of arterial stenosis

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